California Energy Commission

Shale Production Uncertainty Cases: A Scenario Examination

Preliminary Results

2013 IEPR

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Shale Production Uncertainty Scenario Cases
Background

- **NG production from shale formations has soared in the last ten years:**
  - Production in May 2013 exceeded 31 bcf/d
  - Accounts for over 40% of Lower 48 production

- **Accelerated technological innovation has transformed the NG industry**

Shale Production Uncertainty Scenario Cases

Background

- **Controversial Issues:**
  - Groundwater contamination
  - Increased seismic activity
  - Diversion of freshwater
  - Added methane emissions

- **Decision-makers re-examining policies**
  - Delayed development (e.g., New York)
  - Instituted environmental mitigation fees
  - Tightening regulation

Shale Production Uncertainty Cases -16

Start with the Reference Case

Created a sustained High Technology Environment

Two levels of Production Capacity Availability (PCA)

PCA = Constrained

Four levels of Environmental Mitigation Cost (EMC) per Mcf: Shales/Conventionals

- **EMC = $0.00/$0.00**
- **EMC = $0.30/$0.30**
- **EMC = $0.55/$0.30**
- **EMC = $0.67/$0.30**

PCA = Unconstrained

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Shale Production Uncertainty Scenario Cases

Disaggregation of Cases

- Impact of technology
  - High Technology cases vs Low Technology cases
- Impact of policies on development and/or production
  - Unconstrained cases vs Constrained cases
  - Changes in the size of the resource base
  - Changes in the availability of productive capacity
- Impact of environmental mitigation fees
  - Group I cases vs Group II cases vs Group III cases vs Group IV cases
    - Group I: (Shale - $0.00, Conventional - $0.00)
    - Group II: (Shale - $0.30, Conventional - $0.30)
    - Group III: (Shale - $0.55, Conventional - $0.30)
    - Group IV: (Shale - $0.67, Conventional - $0.30)

Shale Production Uncertainty Scenario Cases
Relation to Four Previous Cases

- **Shale Abundance**
  - High Technology, EMC = $0.30/$0.30, unconstrained
- **Shale Reconsidered**
  - Low Technology, EMC = $0.55/$0.30, constrained
- **Shale Expensive**
  - Low Technology, EMC = $0.67/$0.30, constrained
- **Shale Deferred**
  - High Technology, EMC = $0.55/$0.30, constrained

Shale Production Uncertainty Scenario Cases
Key Change Variables

- Changes in four key variables relative to the reference case
  - Changes in the supply cost curves
    - Resource size ranges from 15% increase to 15% decrease
  - Changes in the rate of growth of technological innovation

As the learning rate increases, cost reductions reach the learning limit at a faster rate.

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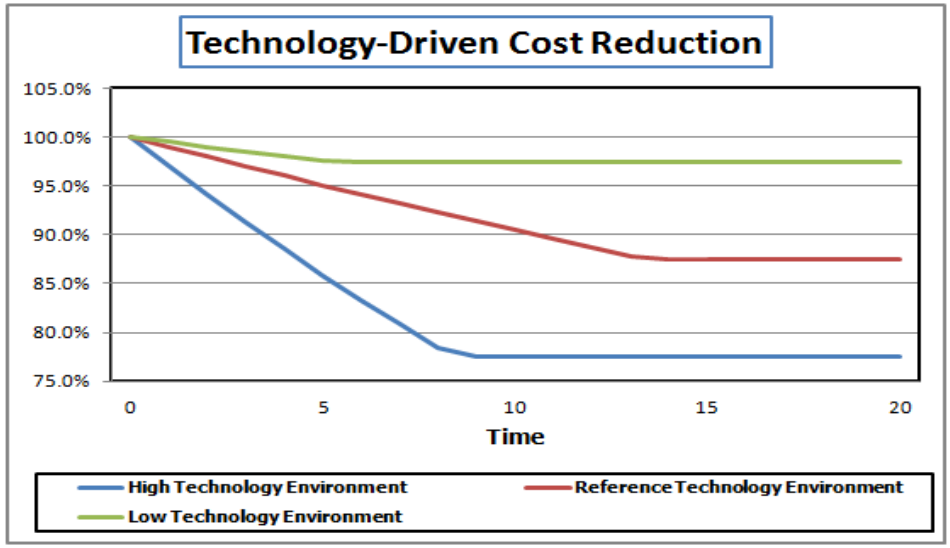
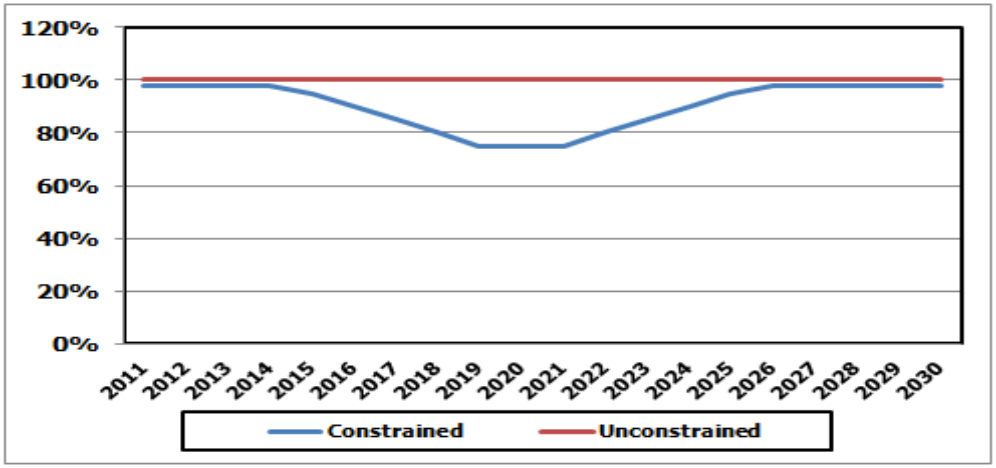


Shale Production Uncertainty Scenario Cases
Key Variable Changes (cont'd)

- Changes in the time of availability of some resources



- Changes in environmental mitigation cost
  - Ranged from $0.0 to $0.67 per Mcf

Shale Production Uncertainty Scenario Cases
High Technology vs Low Technology

Sustained High Technology Environment:

Learning Rate: 3%

Cost Reduction Limit: 77.5%

Underestimation of Shale Resources: 15%

Sustained Low Technology Environment:

Learning Rate: 0.5%

Cost Reduction Limit: 97.5%

Overestimation of Shale Resources: 15%

Shale Production Uncertainty Scenario Cases

Performance of Cases:
2020 Results

Shale Production Uncertainty Scenario Cases: Understanding the Results

- Three effects in following schematics:
  - **Effect of Technology**
    - Compare side by side schematics
  - **Effect of Environmental Mitigation Cost**
    - Discern trend by moving left to right within each schematic
  - **Effect of production constraint**
    - Compare blue bars to red bars (sitting next to each other)

- All schematics show changes relative to Reference Case (0.00%)

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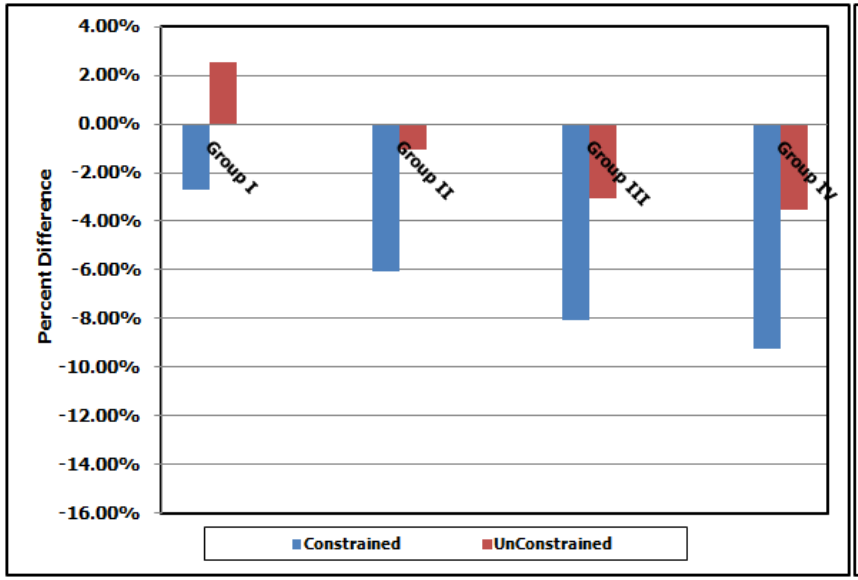
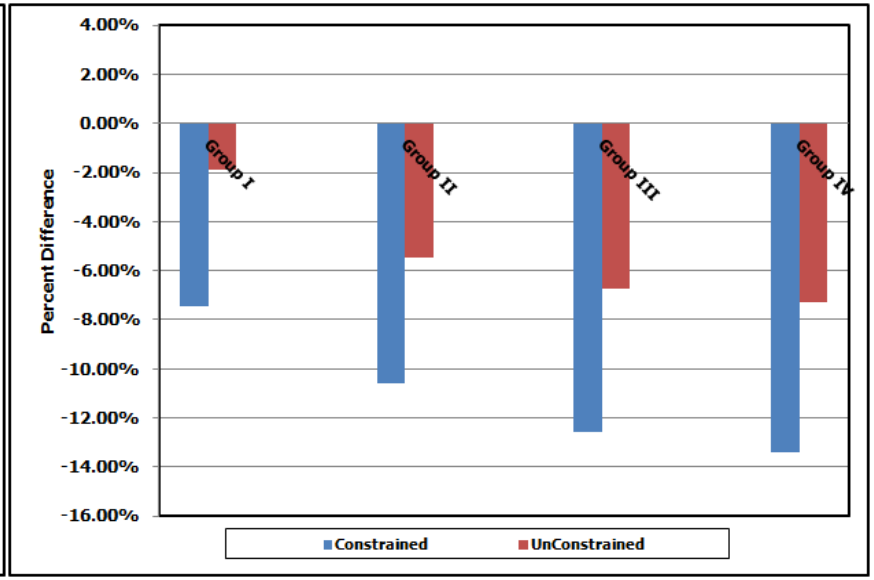
L48 Total Production

(Change relative to Reference Case)



Sustained High Technology: L48 Total Production



Sustained Low Technology: L48 Total Production

Sustained Low Technology environment impacts NG supply more than a Sustained High Technology environment

EMC

Group I: (Shale - $0.00, Conventional - $0.00); Group II: (Shale - $0.30, Conventional - $0.30);
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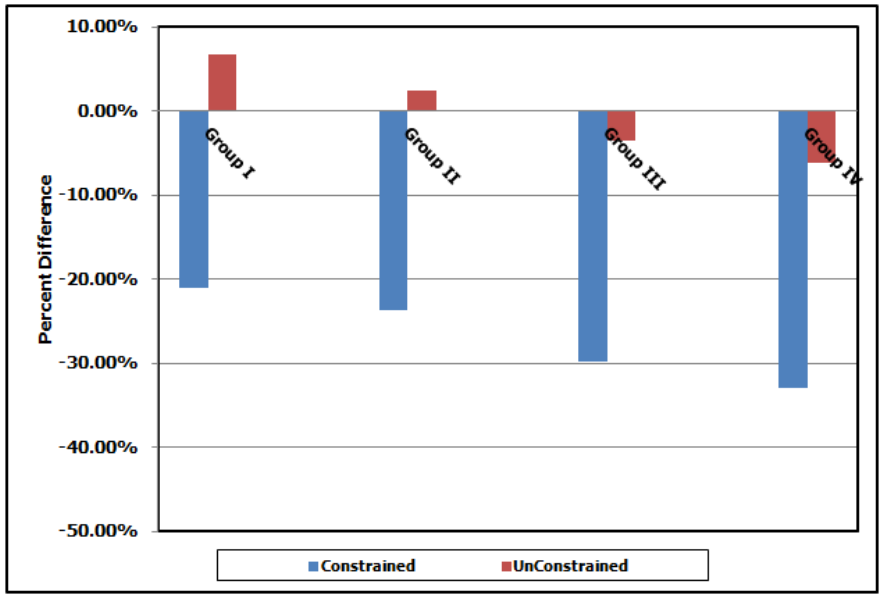
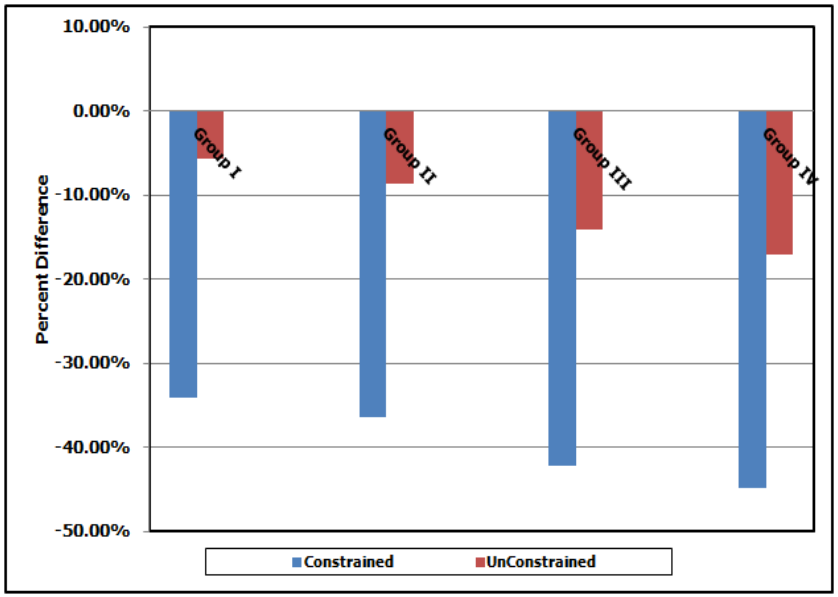
L48 Shale Production

(Change relative to Reference Case)



Sustained High Technology: L48 Shale Production



Sustained Low Technology: L48 Shale Production

Increasing Environmental Mitigation Cost can result in larger reductions in shale production

EMC

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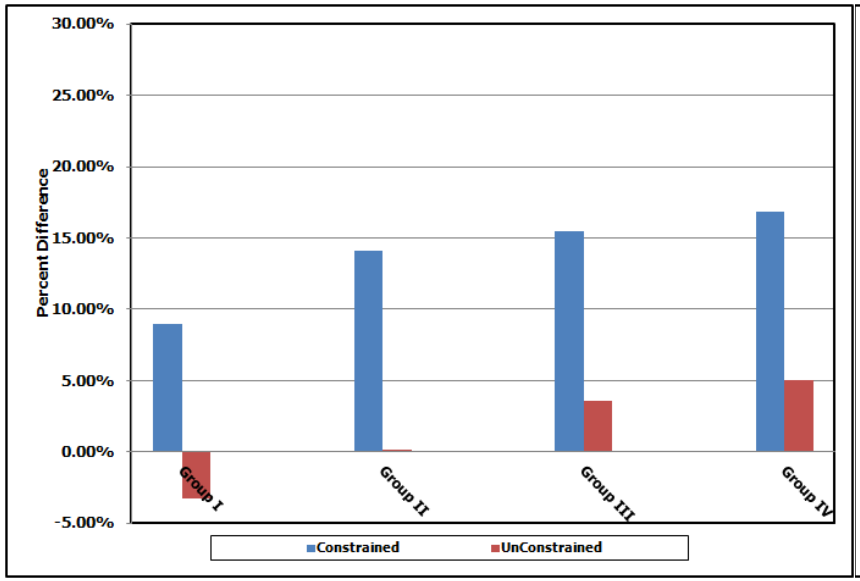
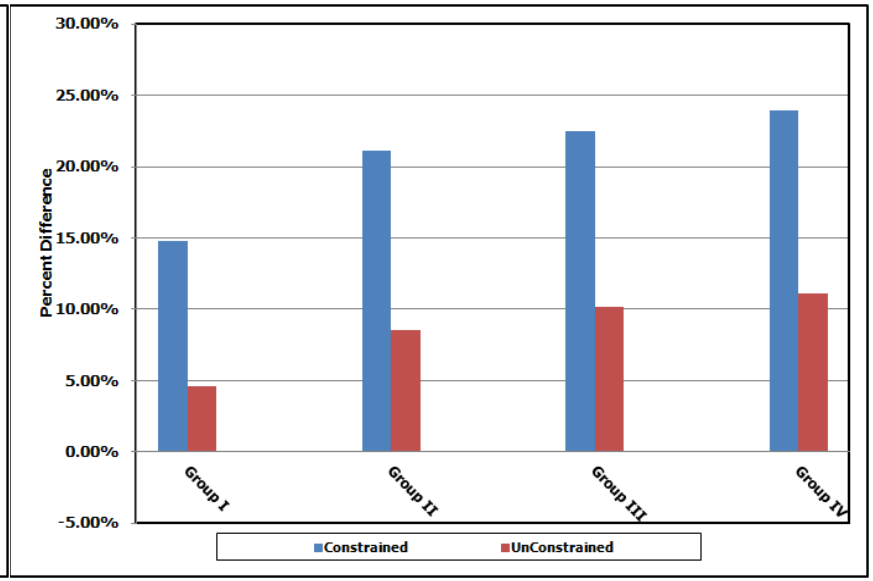
Henry Hub Prices

(Change relative to Reference Case)



Sustained High Technology: Henry Hub Prices



Sustained Low Technology: Henry Hub Prices

Constraints on production can result in larger price impacts

EMC

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Shale Production Uncertainty Scenario Cases: Conclusions and Insights

- **Constraining NG from shale formations significantly impacts prices and supply**
- **Proliferation of technological innovation reduces impacts:**
  - Cost reduction
  - Water handling
- **Environmental policies alter development and production outcomes**
- **Environmental impact fees alter the structure of the natural gas supply portfolio**

Shale Production Uncertainty Scenario Cases

Questions & Comments